SELECTED HIGHLIGHTS FROM THE PHENIX EXPERIMENT

Ming Liu, (for Hubert van Hecke)
for the PHENIX collaboration

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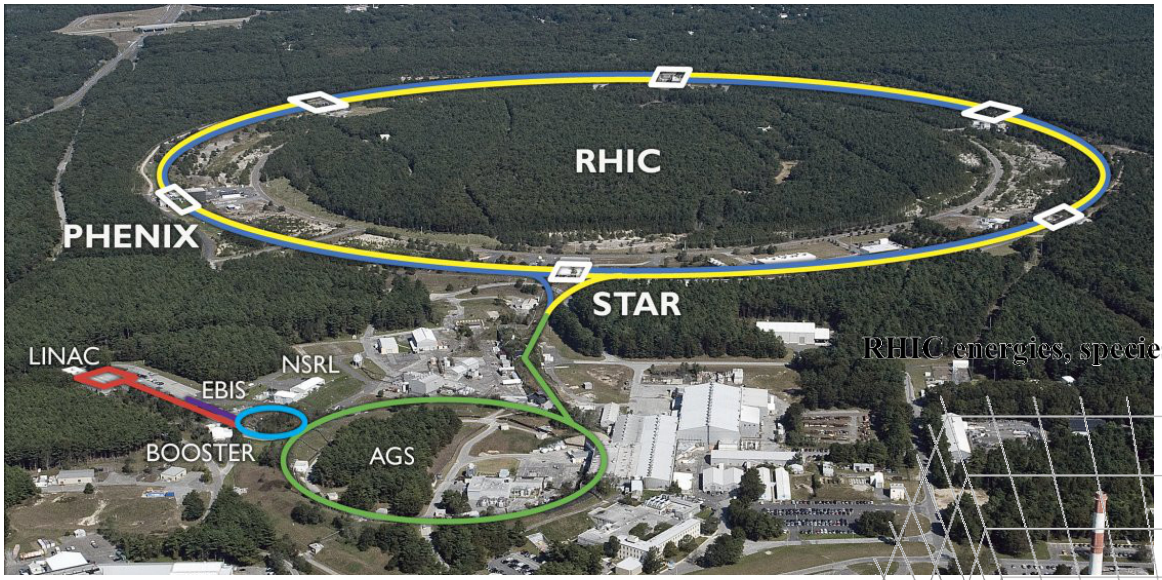
Selected highlights from PHENIX

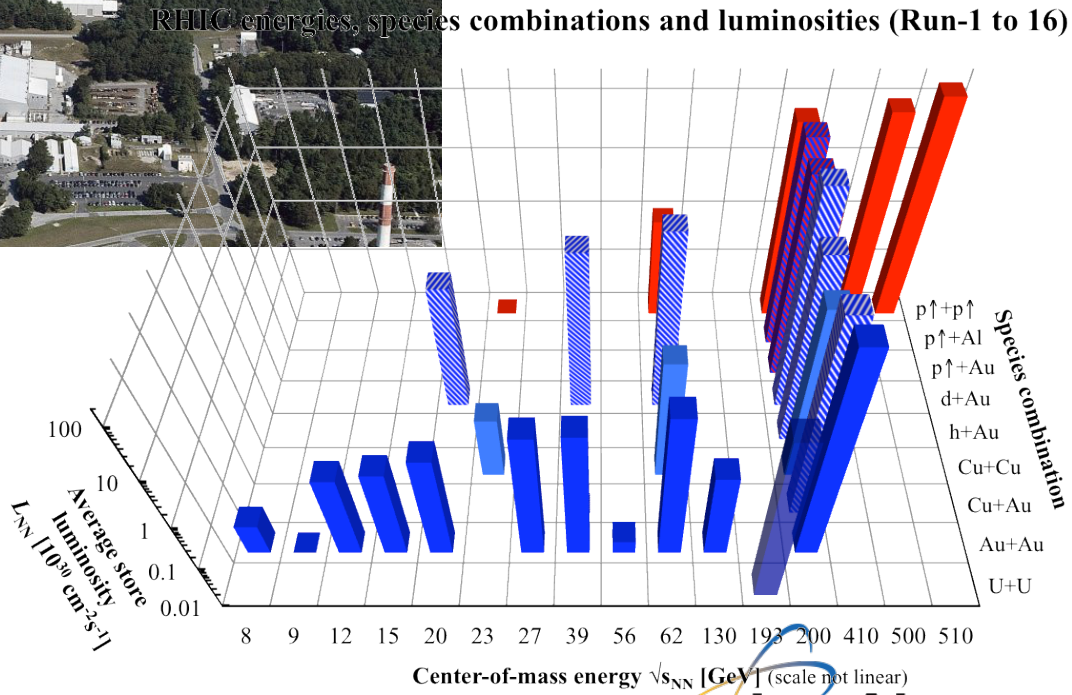
1. ψ/ψ' in pp and pA
2. Open heavy flavor D, B
3. Flow in Small systems
4. Thermal Photons

New results, and some unresolved older measurements

The RHIC accelerator complex



RHIC has collided many different systems at many different energies



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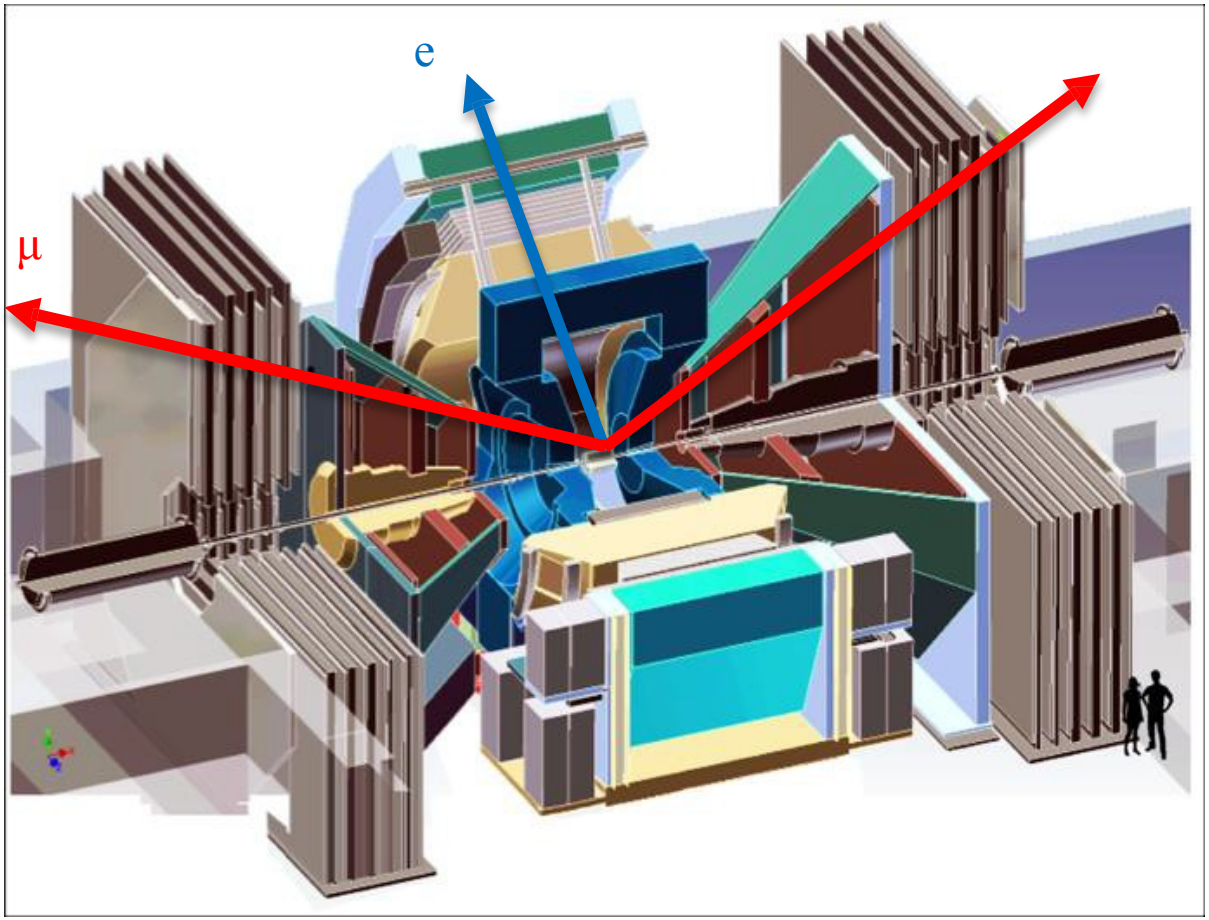
The PHENIX Detector

- **Central Electrons**
  - $|\eta| < 0.35$
  - $\Delta\phi = \pi$
  - Tracking: DC, PC, VTX
  - eID: RICH, EMcal

- **Forward Muons**
  - $1.2 < |\eta| < 2.2$
  - $\Delta\varphi = 2\pi$
  - ~10λ absorber
  - Tracking: wire chamber
  - MuID: 5 layers of steel and Larocci tube plane
  - FVTX



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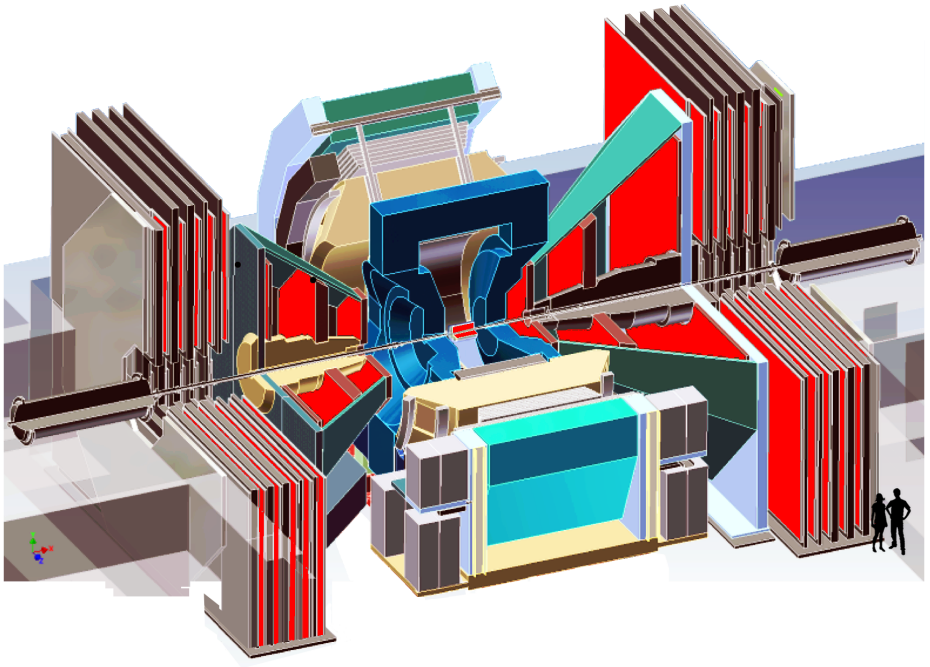
Jψ/ψ'→$\mu^+\mu^-$

Heavy quarks
- Are produced only in initial-phase, hard processes
- Production is calculable in perturbative QCD



- $c\bar{c}$ becomes Jψ, ψ' after formation time, outside nucleus
- Binding energies are very different (640, 50 MeV)
- Differences between Jψ, ψ' reflect final state effects

Detectors used:
- Forward Vertex Detector
- Muon Tracker
- Muon Identifier

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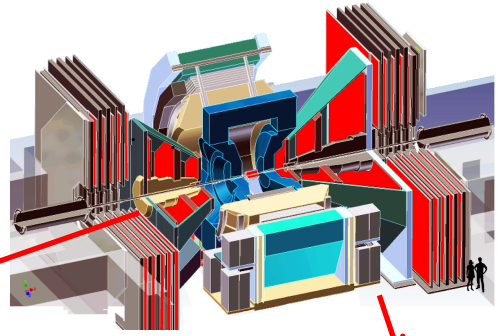
Jψ/ψ'→$\mu^+\mu^-$ in p+p



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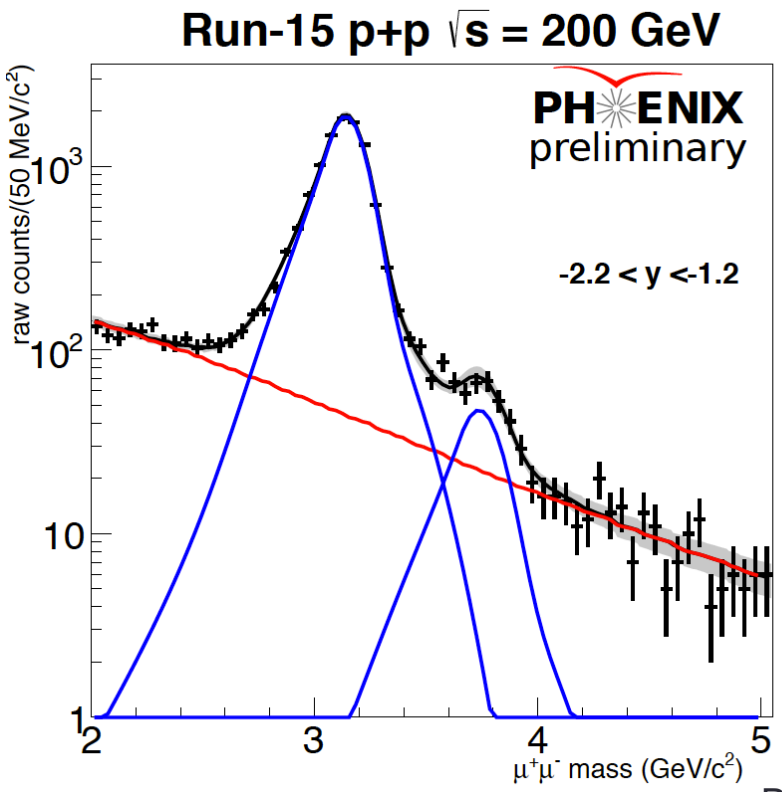

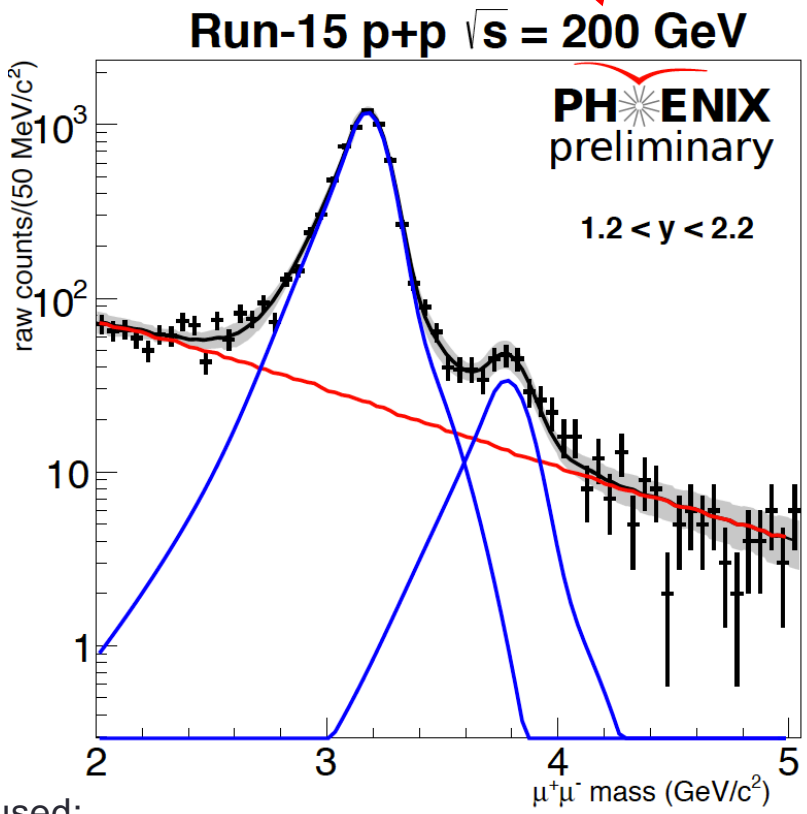

Detectors used:

- Muon Tracker
- Muon Identifier
- Forward Vertex Tracker

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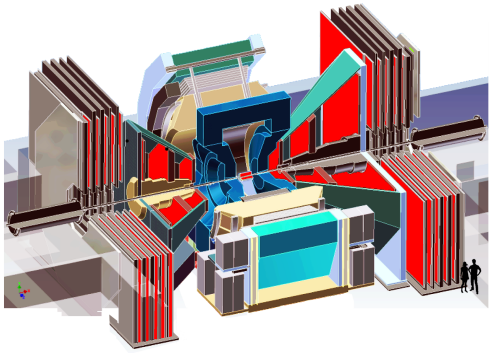
Jψ/ψ'→$\mu^+\mu^-$ in p+p



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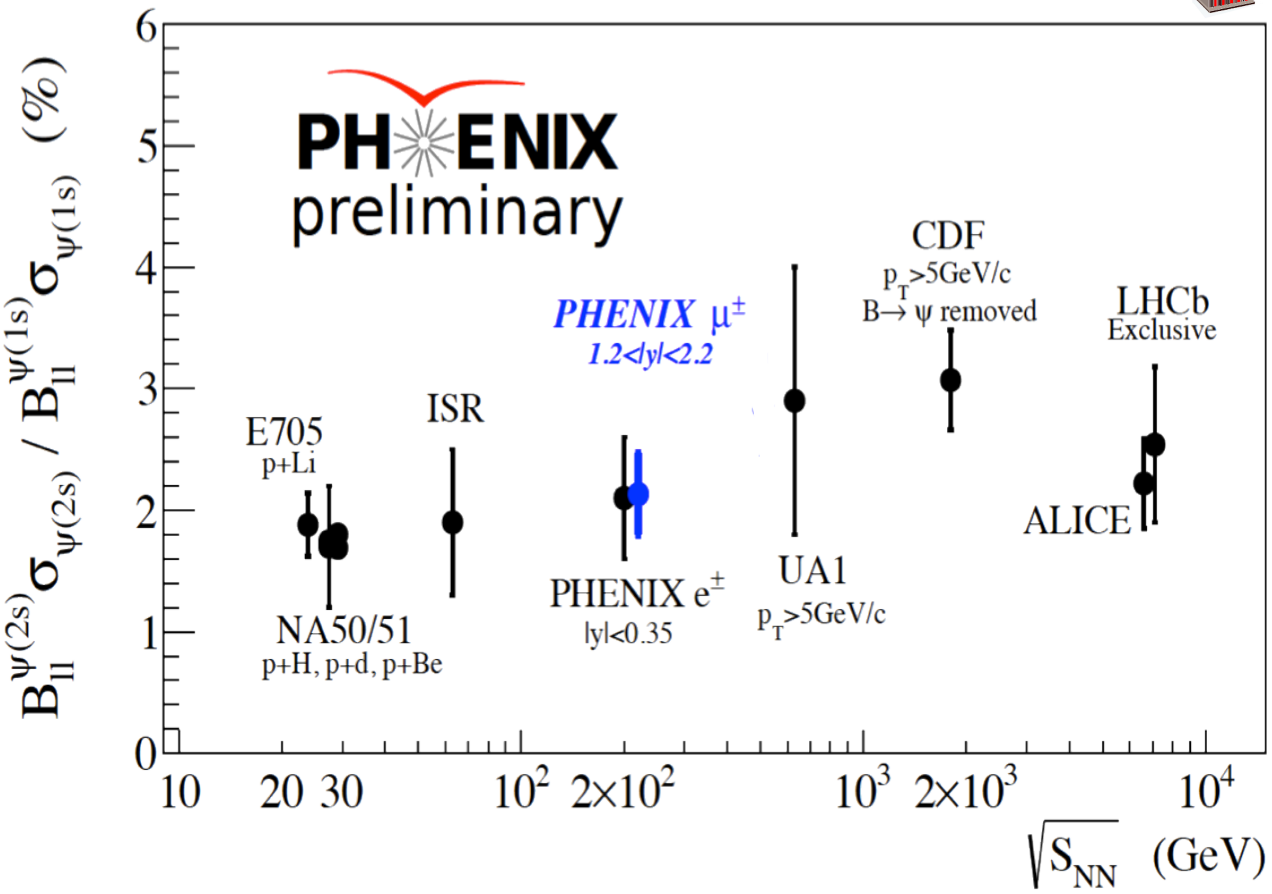

Ratio in pp matches world data

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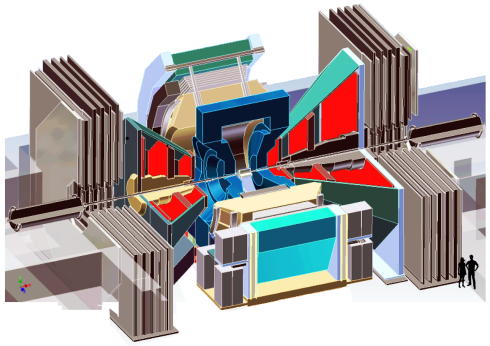
Jψ/ψ'→$\mu^+\mu^-$ in p+p



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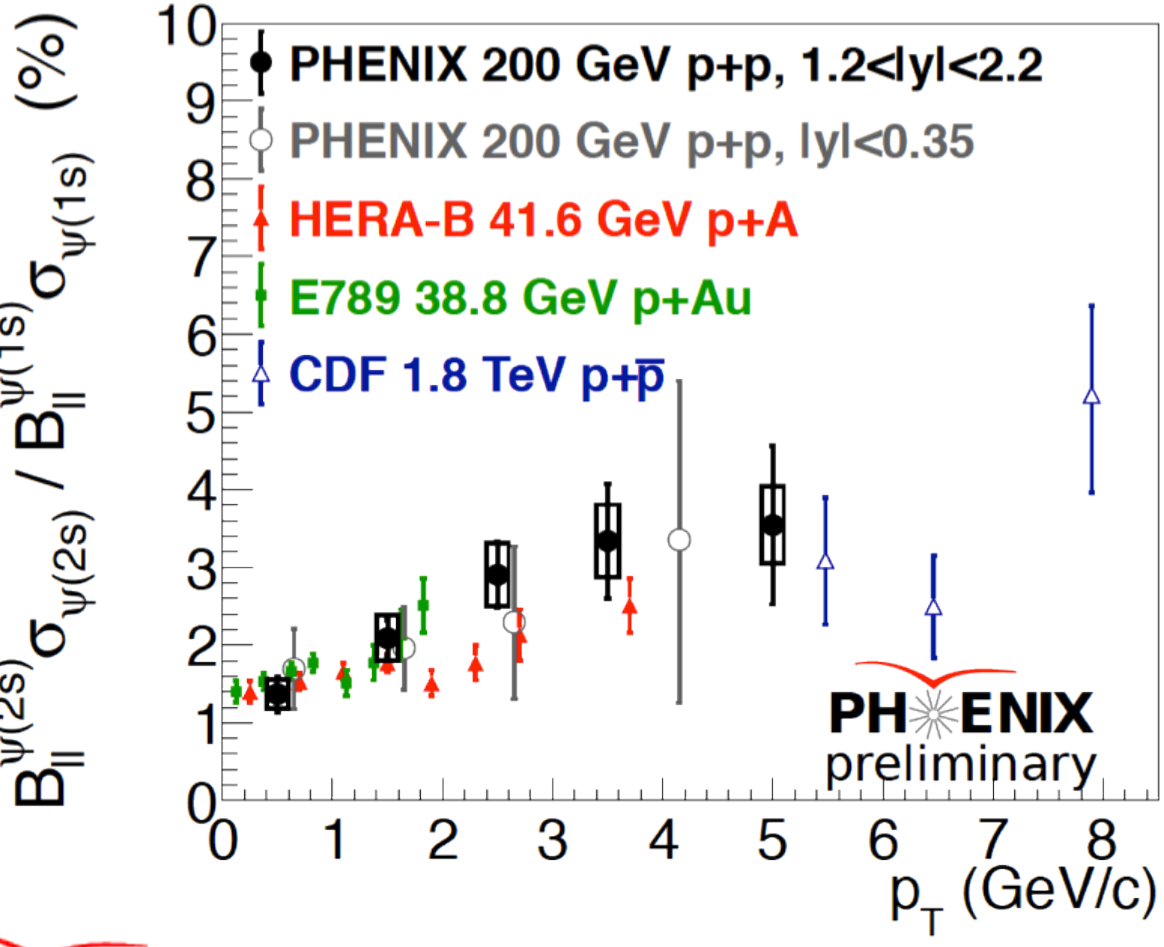

p_T spectrum Consistent with world pp, p$\bar{p}$ data at lower and higher energies

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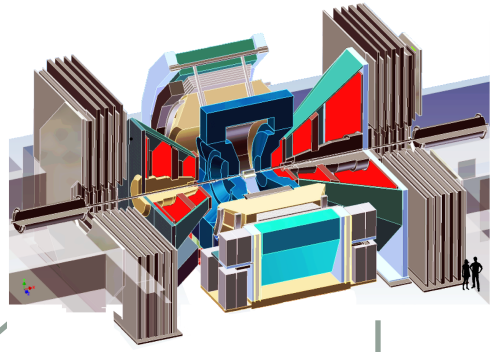
Jψ/ψ'→$\mu^+\mu^-$ in pA

Run-15: p+Au, p+Al, d+Au



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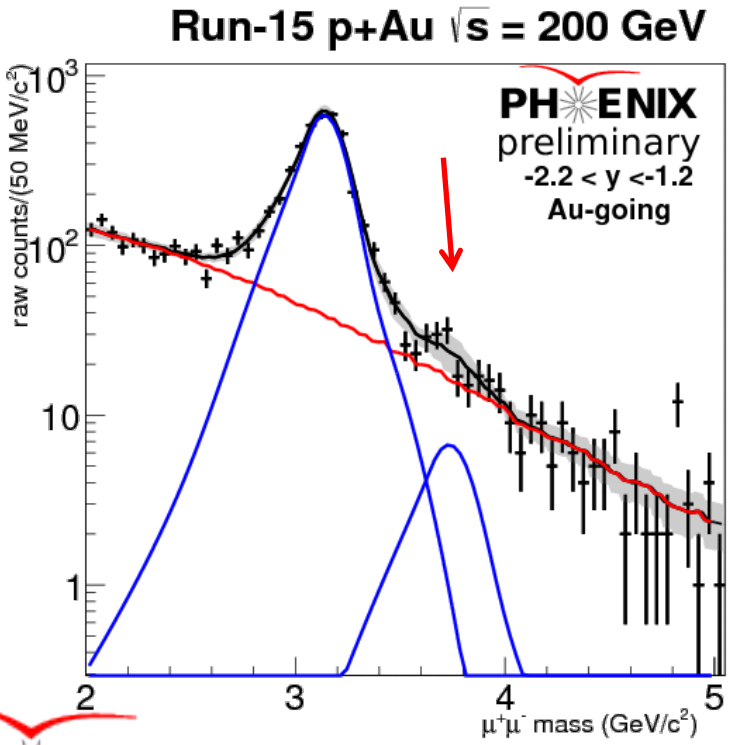

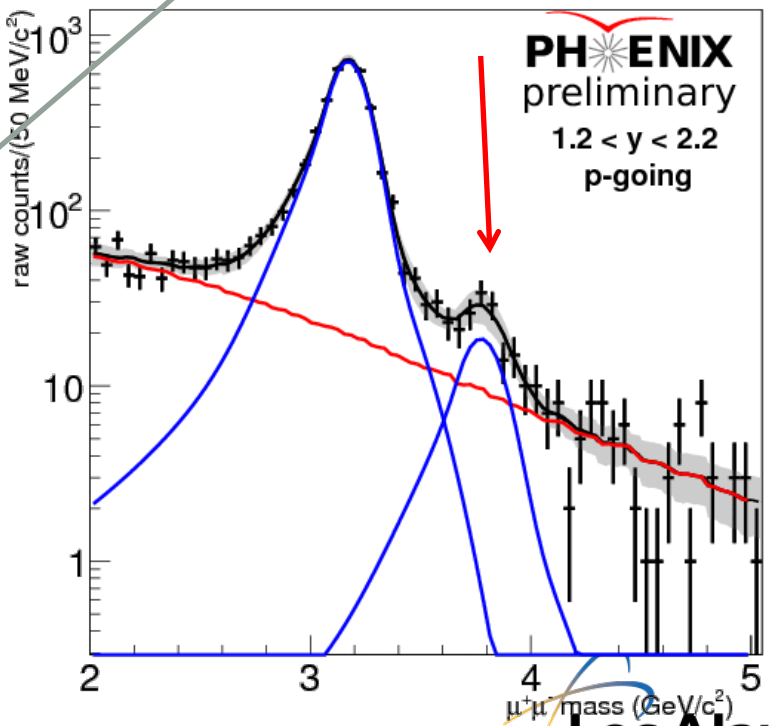

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Jψ/ψ'→$\mu^+\mu^-$ in pA

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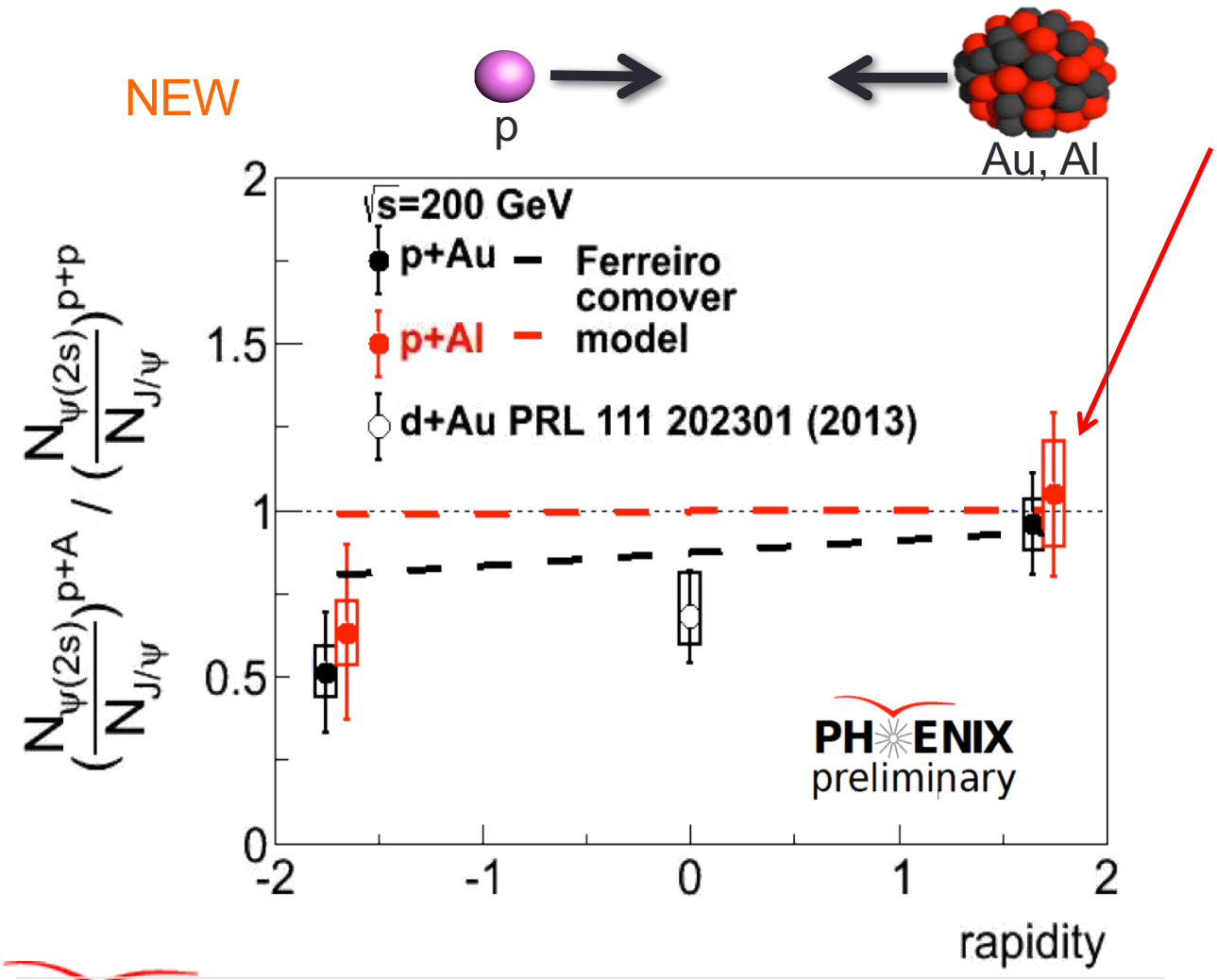

Ψ(1s), Ψ(2) affected the same in the (low-density) p-going direction.

Suppression by ~2 in the Au,Al-going direction can be attributed to interactions with co-movers.

However, densities in A-going direction in Al, Au are not the same, but suppression is. Need theory.

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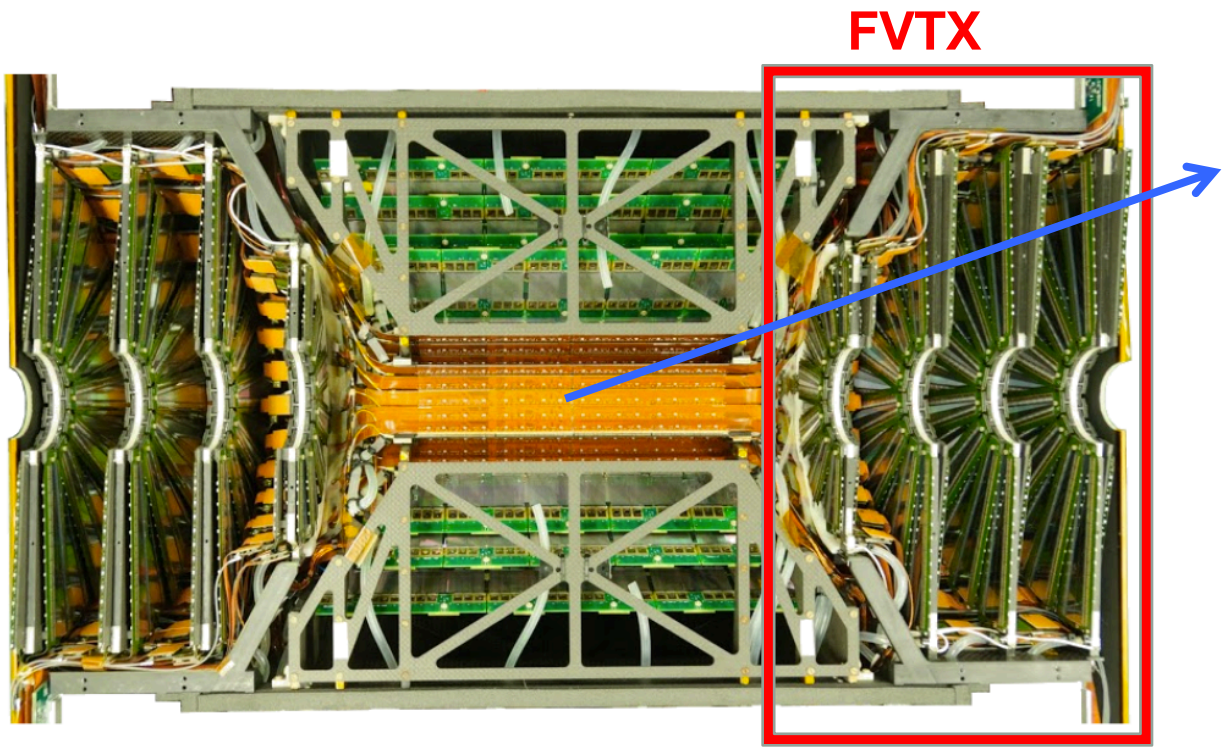
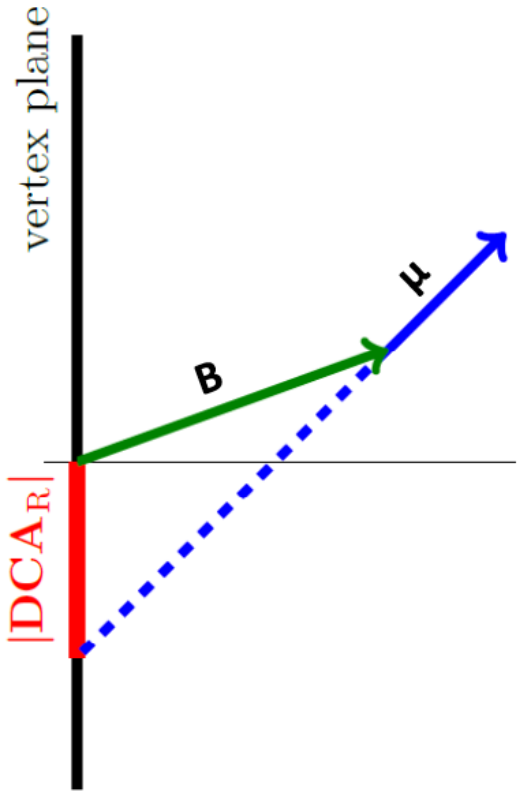
B→J/ψ

J/ψ produced from B decay are sensitive to different initial state and final state effects on B production than J/ψ produced directly in heavy ion collisions.

Measurement of B->J/ψ helps constrain gluon PDFs in different regions of x and Q^2 in p+p collisions

B→J/ψ in pp and CuAu





B→J/Psi fraction was measured from precise measurement of DCA_R in

- pp 510 GeV
- Cu+Au 200 GeV

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B→J/ψ in pp 510 GeV

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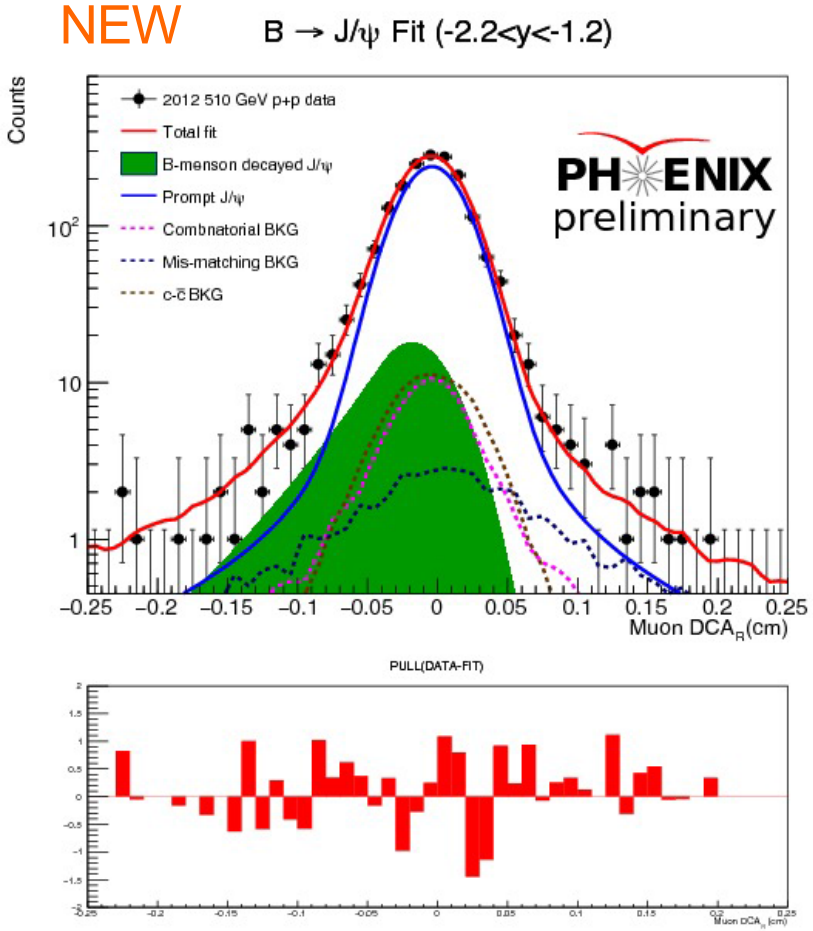
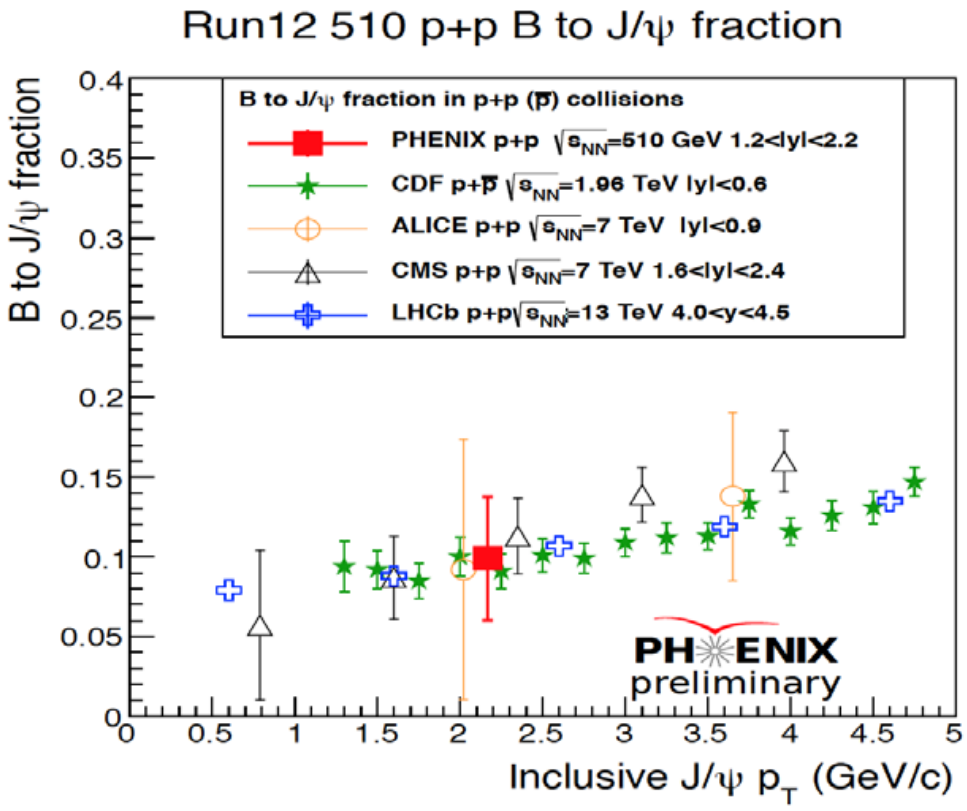


Determine and unfold all contributions



Consistent with measurements at higher energies

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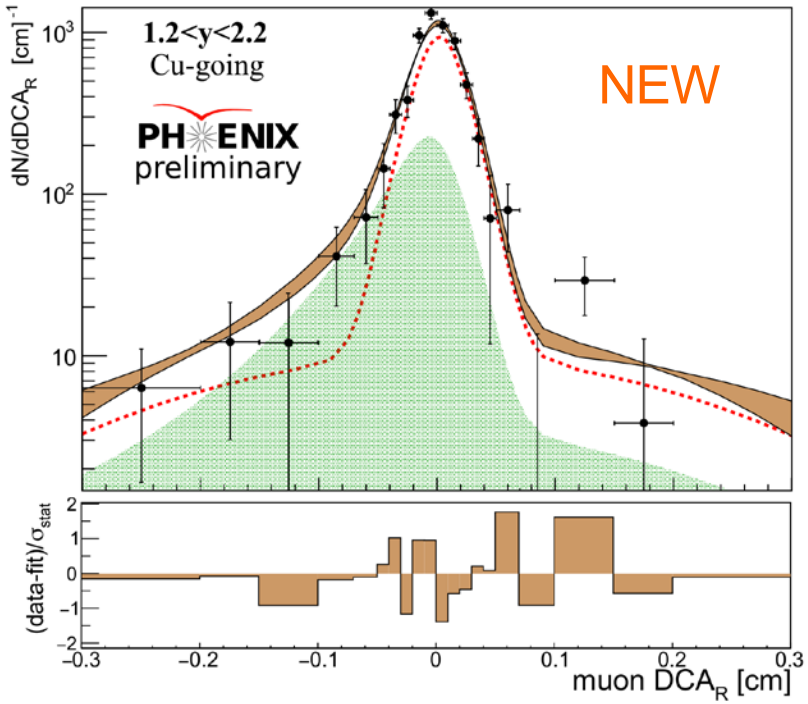
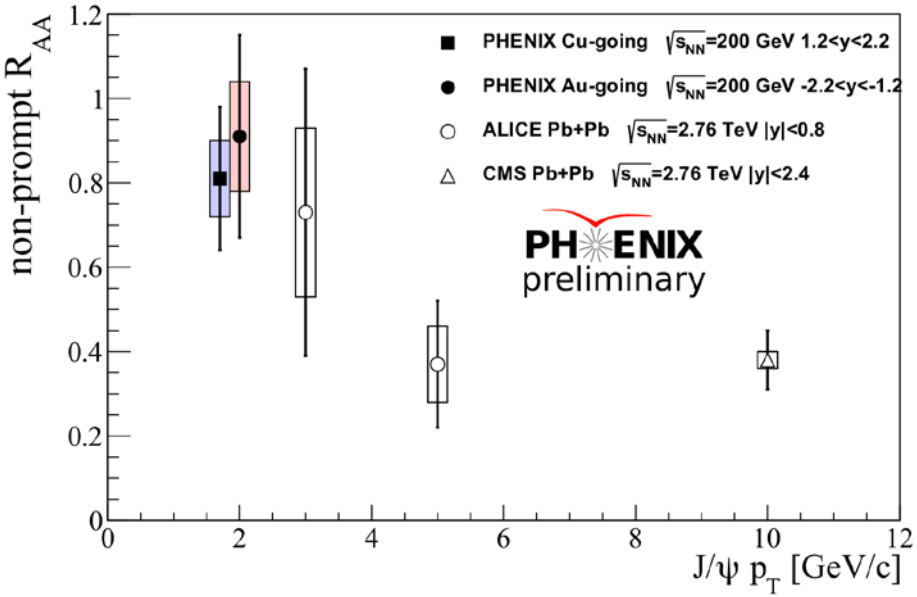
B→J/ψ in Cu+Au 200 GeV



Determine and unfold all contributions



Convert the B->J/Psi fraction to R_{AA} assuming that B->J/Psi fraction in p+p is 0.1

$$R_{AA}^{B\to J/\psi} = \frac{F_{B\to j/\psi}^{AA}}{F_{B\to j/\psi}^{pp}} R_{AA}^{J/\psi} = \frac{F_{B\to j/\psi}^{AA}}{0.1} R_{AA}^{J/\psi}$$

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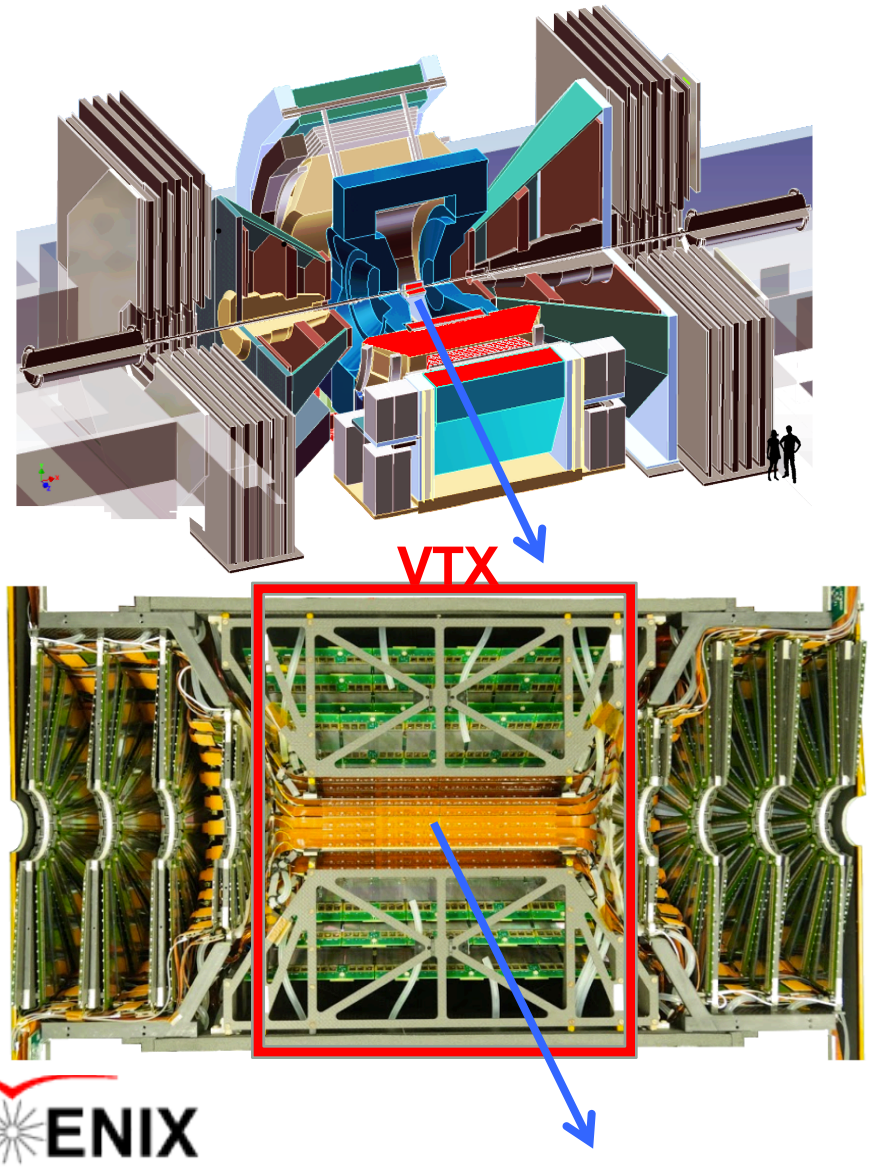
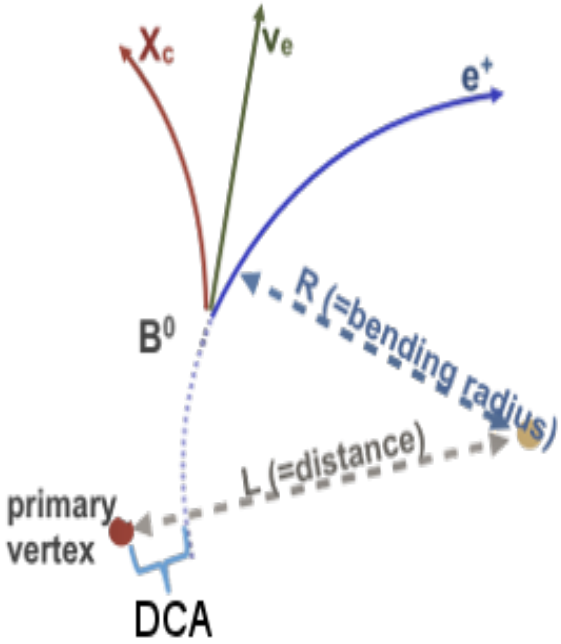
D/B separation using secondary vertices





D, B produced in initial hard processes, preserved throughout

VTX, central rapidity, using electrons

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R_{AA} for D,B → electrons

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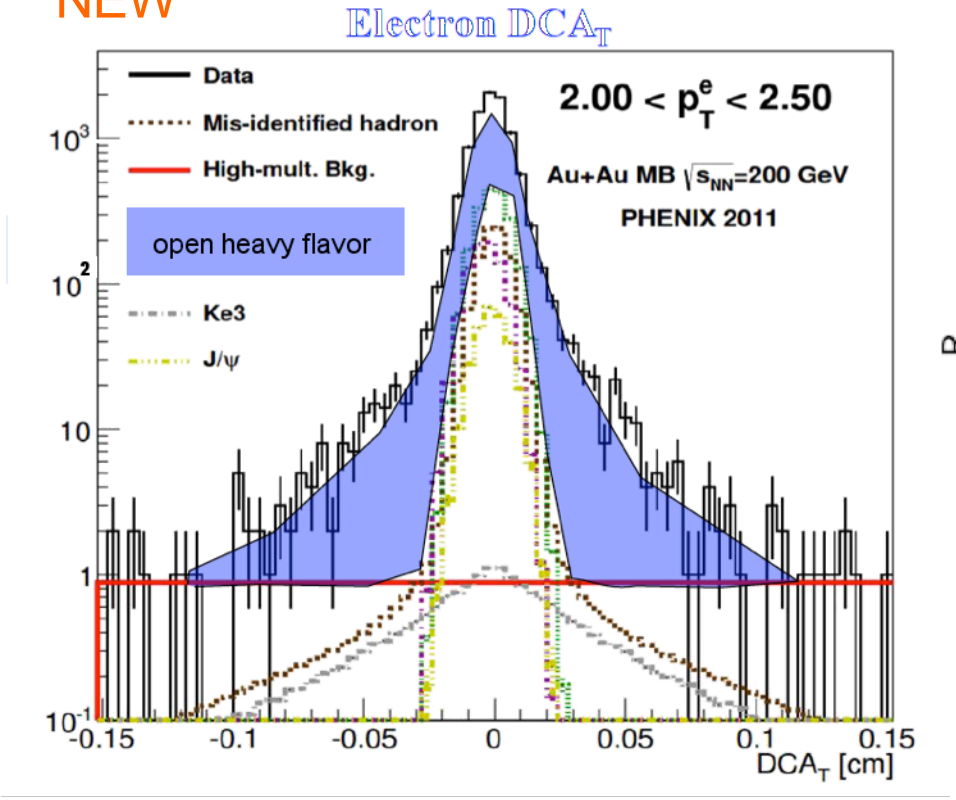
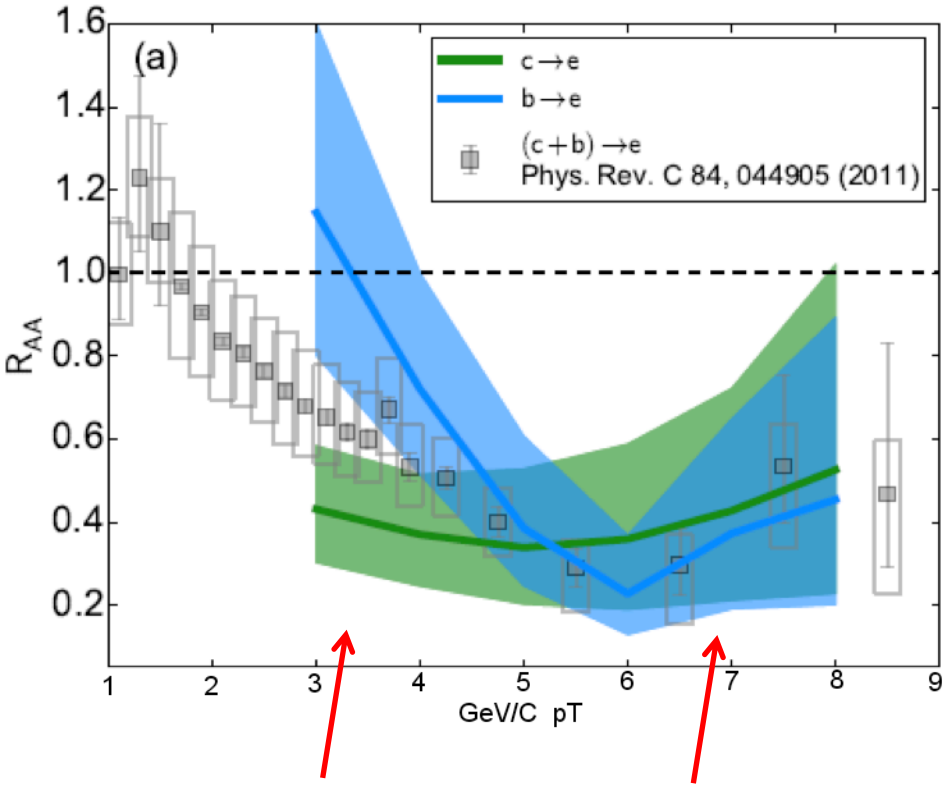


Phys. Rev. C93, 034904 (2016)



Low p_T: B less suppressed than D

High p_T: B and D similarly suppressed

~20x more data coming

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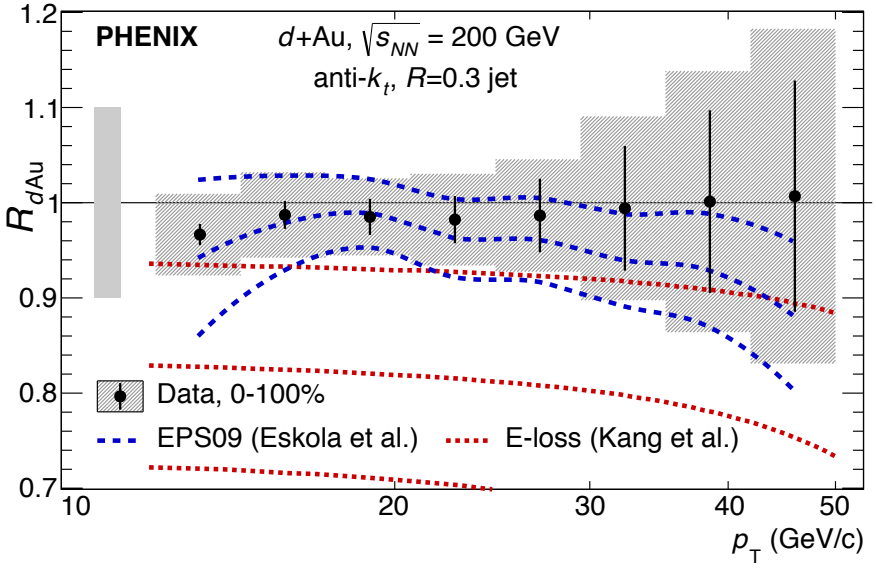
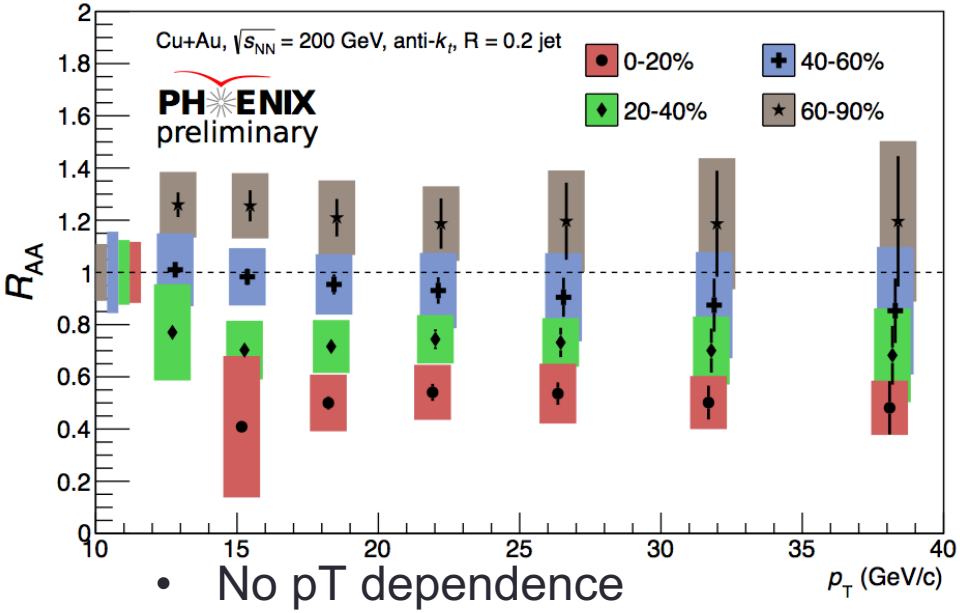
Jets in Cu+Au and d+Au

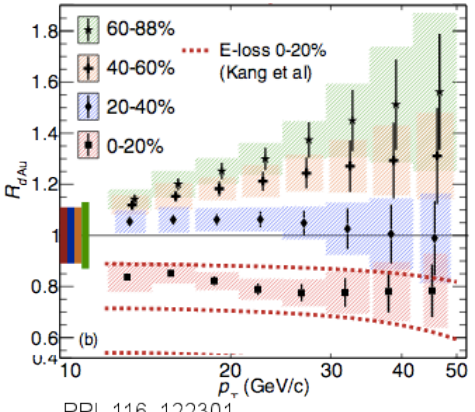
Phys. Rev. Lett. **116**, 122301 (2016)





- No suppression in min bias events
- No p_T dependence
- Consistent with NLO, nuclear effects are small

- No pT dependence
- Clear centrality dependence



PRL 116, 122301

Surprise! We had seen pT dependence in dAu

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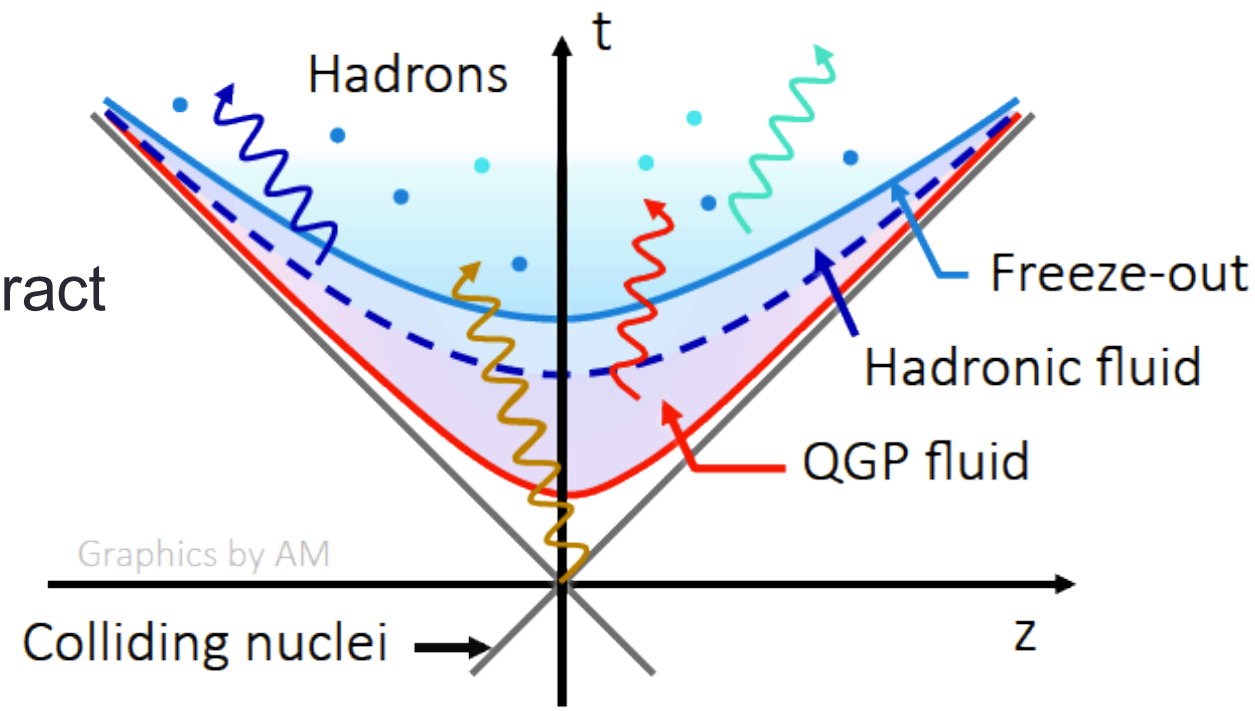
Direct photons

Photons don't interact

Signal from whole event evolution, including the earliest time



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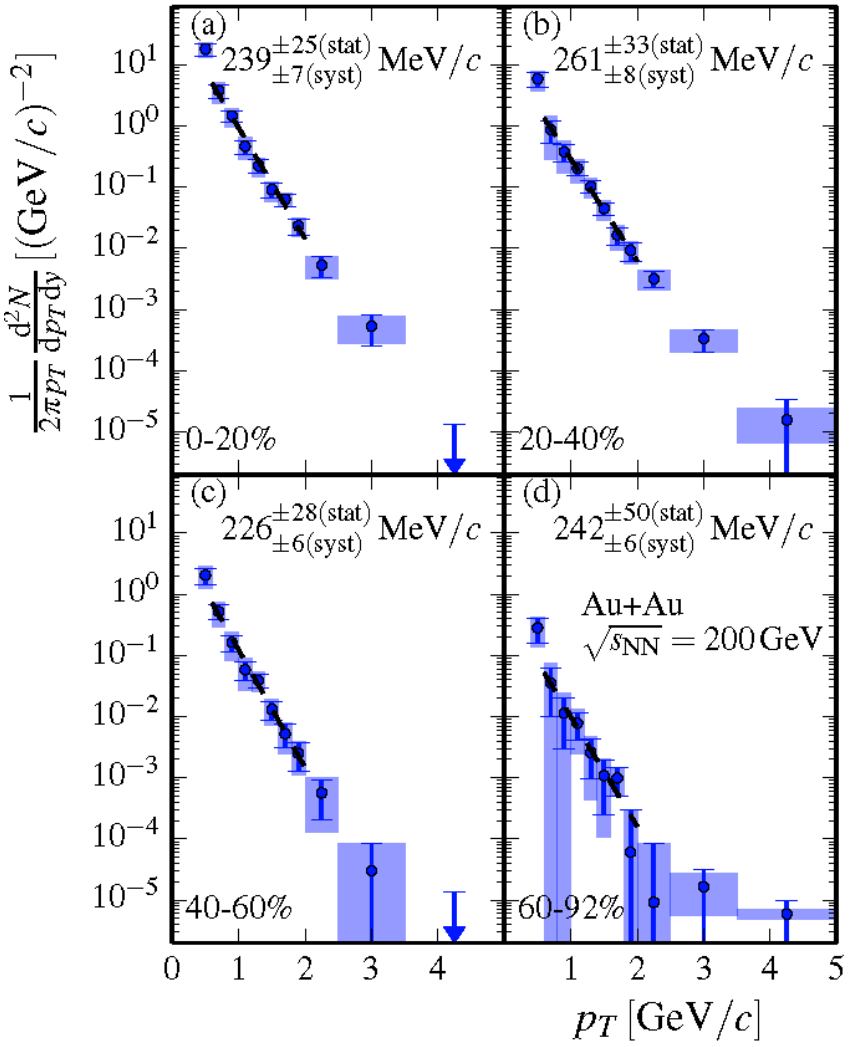
Thermal photon spectra

- Thermal photon spectra are obtained by subtracting hard photons from all direct photon spectra
  - Hard photon contribution is estimated from p+p times Ncoll
- Fitting to low p_T region gives T~240MeV/c, almost independent of centrality
- The Slope parameter reflects the convolution of the instantaneous rates with the time-dependent temperature.
  - One has to assume time profile to obtain the temperature at given time.

PRC 91, 064904 (2015)



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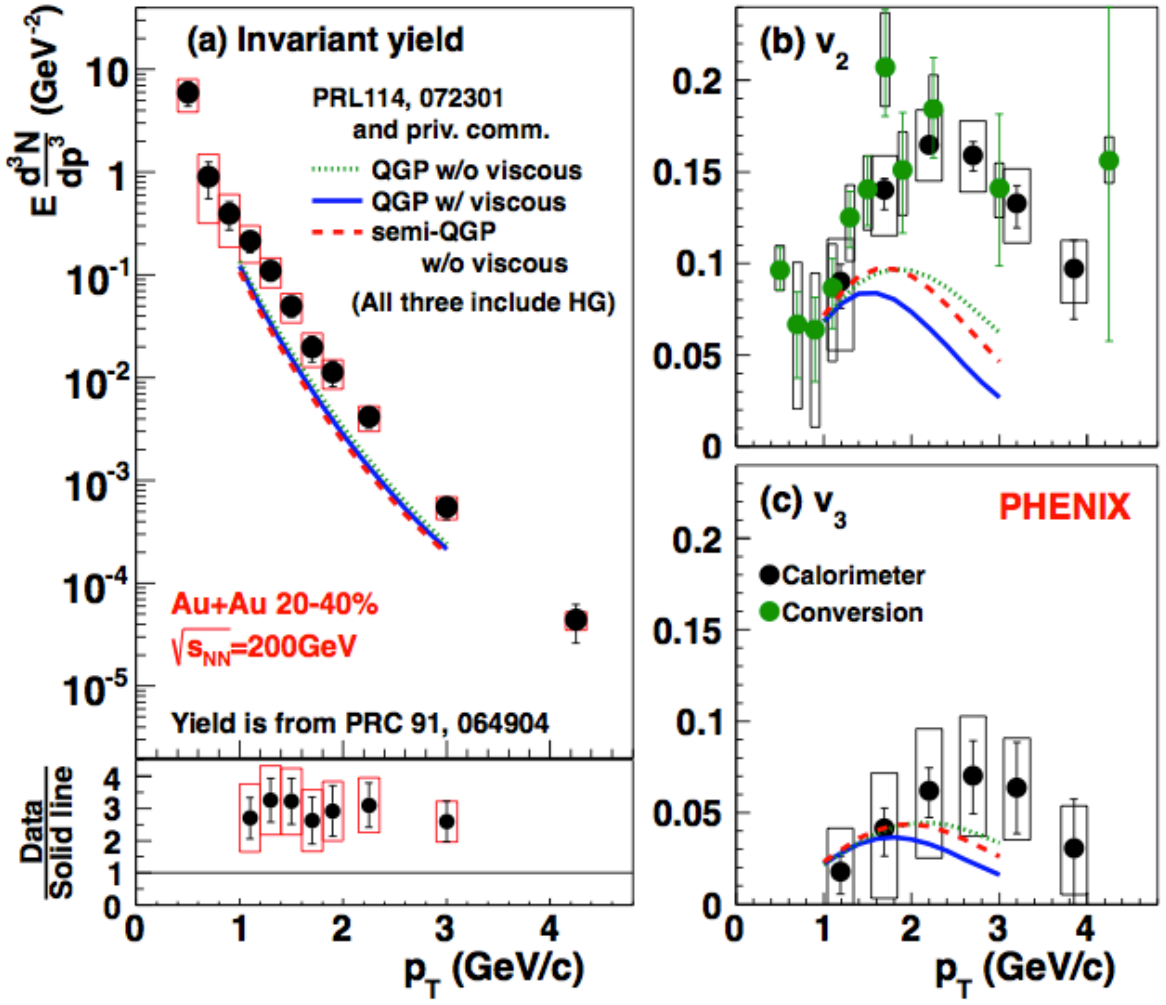
Direct photons in Au+Au



- Yield is large (x3 of models)
- v2 is large (x2 of models)

No good explanation yet. Many more photons need to come from late stages of the collision, when flow has developed

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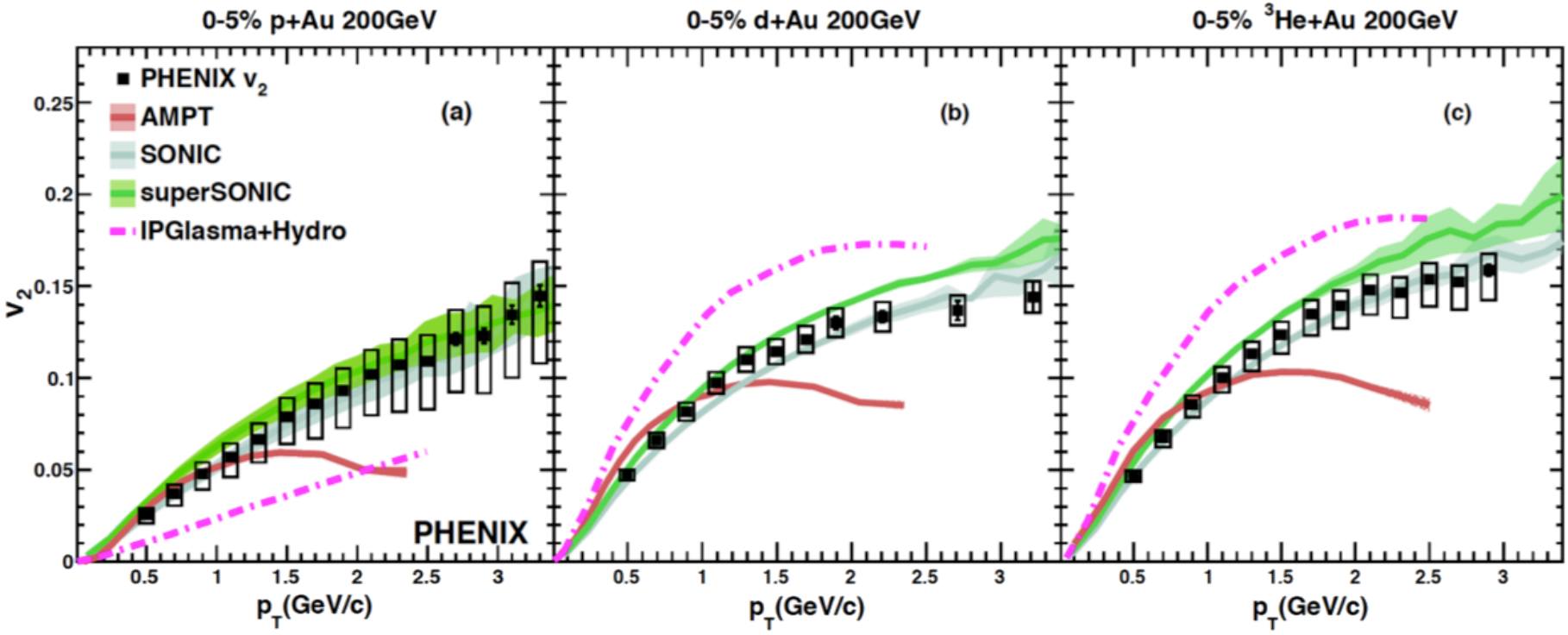
Collective effects in small systems

How small can a system be and still show collective effects?
-> Exploit RHIC's versatility:



Strong flow at RHIC top HI energy.
Sensitive to early system properties

AMPT: arXiv:1501.06880
SONIC: arXiv:1502.04745
IP+Hydro:arXiv:1407:7557

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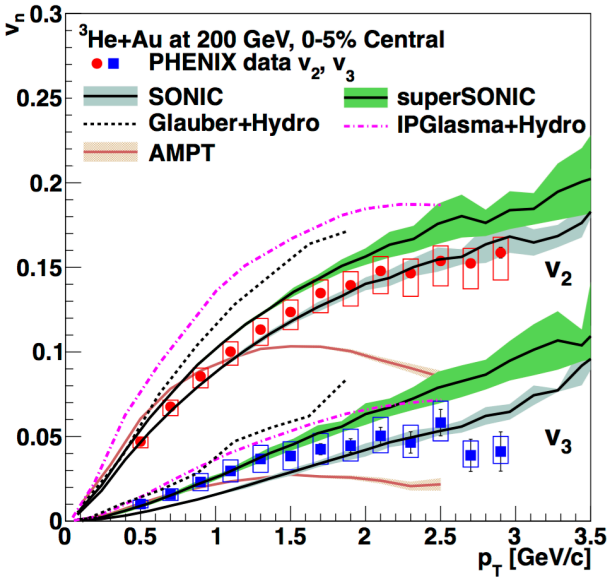
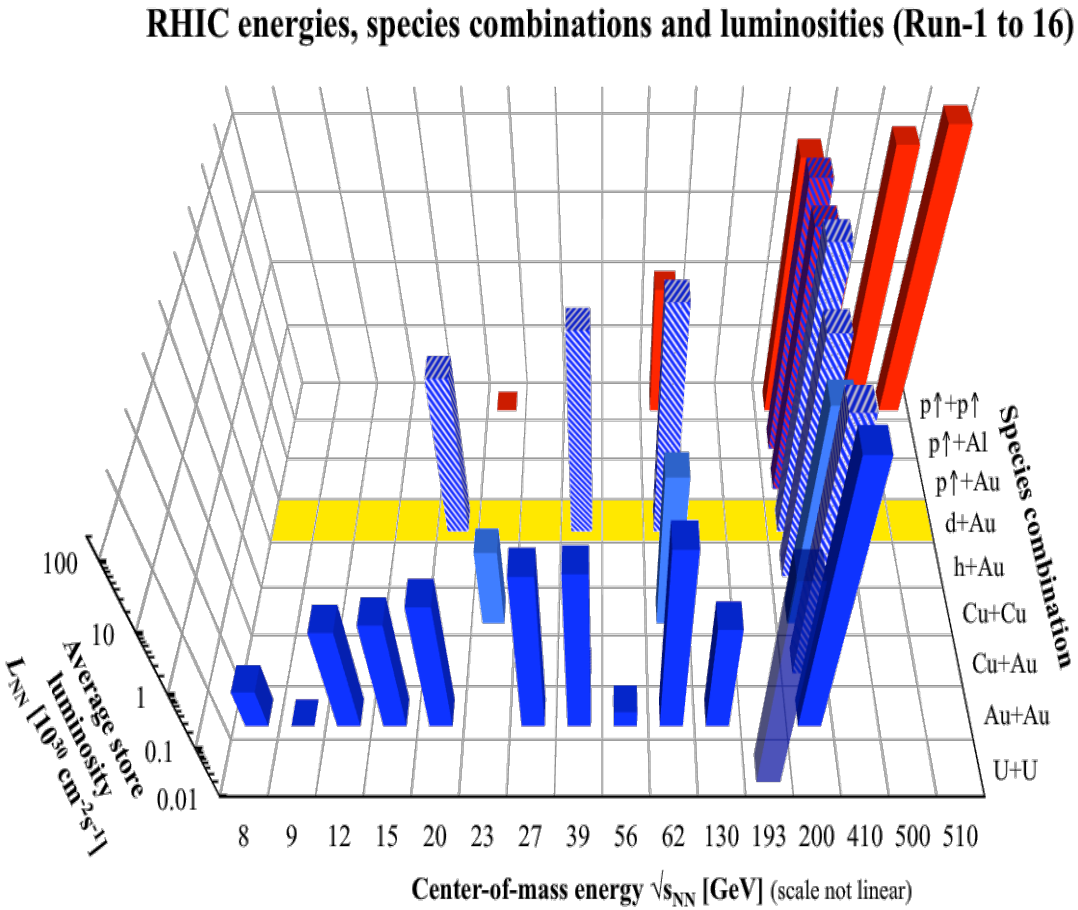
Smaller (dAu) and smaller (lower energy)



v_3 (triangular flow) develops slower, and may not have enough time in smaller, shorter-lived systems

-> watch dAu energy scan (2016) for v_2, v_3 results



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More to come…

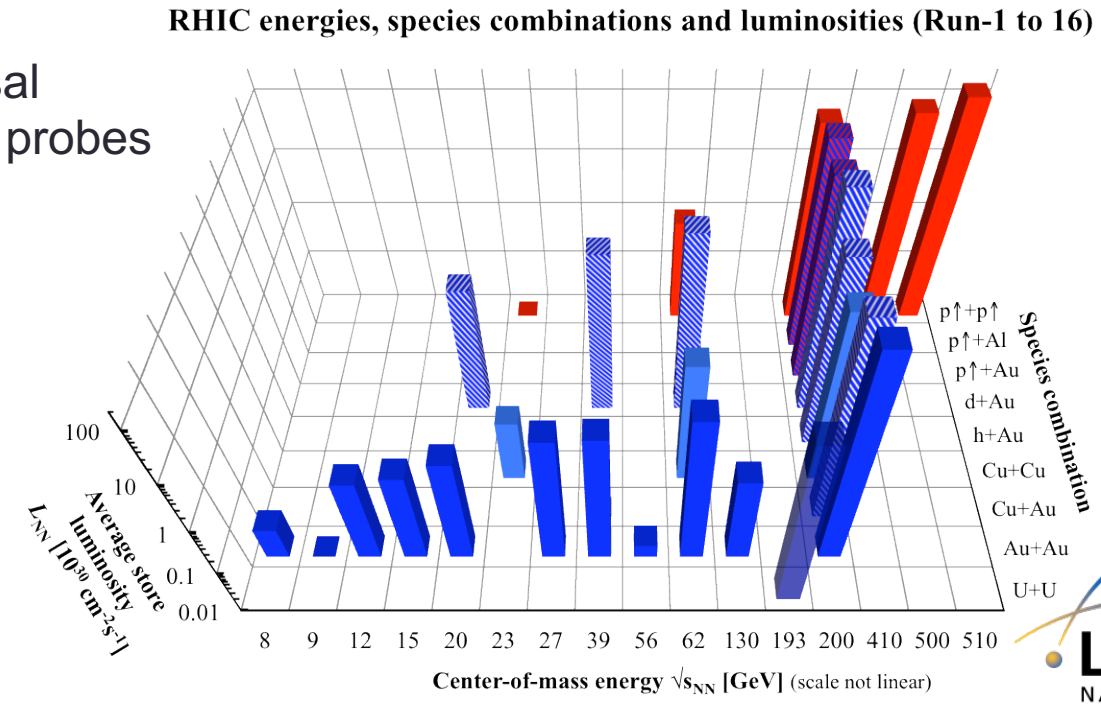
After 25 years, and 16 runs, PHENIX has completed data taking in 6/2016

However, the collaboration remains very much active

Expect 15-20 papers per year for the next 3-5 years

sPHENIX proposal
- Jets and hard probes
- 2022+

Stay tuned!



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Back up

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